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Optically stimulated luminescence (OSL) and its applications in radiation therapy dosimetry

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OPTICALLY STIMULATED LUMINESCENCE (OSL) AND ITS APPLICATIONS IN RADIATION THERAPY DOSIMETRY

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CERTIFICATION

I, Bin Hu, declare that this thesis, submitted in partial fulfilment of the requirements for an award of Doctor of Philosophy in the Department of Biological Sciences, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Bin Hu

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Abstract

Optically stimulated luminescence (OSL) was studied using a commercial OSL dosimetry system developed by Landauer (Landauer Inc.,USA) to analyse the possibility of using OSL dosimetry for external beam radiotherapy planning checks and in-vivo dosimetry. Experiments were performed to determine signal sensitivity, dose response range, beam type and energy dependency, reproducibility and linearity. Optical annealing processes to test OSL material reusability were also studied. OSL clinical usability was assessed by verifying IMRT dose distributions in a phantom and measuring exit doses for in-vivo dosimetry.

Experimental results show that OSL dosimetry provides a wide dose response range as well as good linearity and reproducibility for doses up to 600cGy, and up to 800cGy shows a 2.0% maximum deviation from linearity. The standard deviation in the response of screened dosimeters was 2.0%. As this needs to be taken into account when OSLDs are used clinically, multiple readings of each irradiated OSLD are recommended. OSLDs can be reused when an optical annealing process is applied, which can restore the OSLD to its original state. After optical annealing using incandescent light, the readout intensity decreased by approximately 98% in the first 30 minutes, decreasing further after repeated optical annealing according to the power law, $I \propto t^{-1.3}$, where I is the light intensity.

Quantitative comparisons were made between treatment planning system (TPS) calculated dose and OSL measurement points dose using a custom-designed spherical phantom. Three clinical IMRT cases were used: Nasopharynx, Prostate and Lung. Although quantitative comparisons are highly dependent on the calibration accuracy and dose range of OSLDs, experimental results showed that the OSL dose is within 3% of the TPS calculated dose with careful calibration**.** Quantitative comparisons were made between various bactscatter material conditions when performing exit

dosimetry. OSLD dose was 5.7% lower when no backscatter material was added compared to full backscatter. Adding 0.5cm to 1.0cm water equivalent material reduced the dose by 2%. The reduction in dose may vary due to the density of the tissue in the primary beam path. These measurements demonstrated the importance of adding appropriate backscatter material to improve the accuracy of the readings.

One made quantitative comparisons between OSL measurements and the depth dose data from linear accelerator commissioning and those of a Markus ion chamber by using a custom-designed heterogeneous phantom. Compared to the depth dose data, OSL dose is 1% lower in the full backscatter condition, 2% with a 1cm backscatter and there is a maximum of 6% reduction with no additional backscatter added. Compared to the Markus ion chamber OSL readings show an insignificantly lower dose. Added backscatter thickness, field size, energy, tissue or a tumour's size and density along the primary beam path-length, as well as the control/calibration dose will all affect OSL response in in-vivo dosimetry.

The research work shows that OSL dosimetry can be an alternative dosimetry technique for use in radiotherapy, especially for patient specific Quality Assurance (QA) including skin dose measurement, IMRT plan checks, and linear accelerator QA. In conclusion, OSL dosimetry can provide an alternative dosimetry technique for use in radiotherapy if rigorous measurement protocols are established.

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